

1 **Amendment to the Claims**

2 **In the Claims:**

3 Please amend Claims 1, 8, 9, 11, 15, 18, 22, 24, 26, 32, 35, 38, and 40 as follows:

4 1. (Currently Amended) A method for estimating a thickness of a wall of a lumen from an  
5 image of the lumen, comprising the steps of:

6 (a) in an image of the lumen, identifying an inner contour and an outer contour;  
7 (b) performing a low resolution triangulation function to define triangles between  
8 the inner contour and the outer contour;

9 (c) adding additional triangles between the inner contour and the outer contour;

10 (d) analyzing edges of the triangles that were defined and added using a minimal  
11 energy function to identify triangle edges that correspond to a width between the inner contour and  
12 the outer contour; ~~and~~

13 (e) comparing triangle edges identified as corresponding to a width between the  
14 inner contour and the outer contour to identify a minimum width and a maximum width  
15 corresponding respectively to a minimum wall thickness and a maximum wall thickness of the  
16 lumen; and

17 (f) having identified the minimum width and the maximum width, executing at  
18 least one step selected from the group consisting of the following steps:

19 (i) storing indications of the minimum width and the maximum width for  
20 later use; and

21 (ii) outputting indications of the minimum width and the maximum width  
22 to a user.

23 2. (Original) The method of Claim 1, further comprising the steps of repeating steps (c) and  
24 (d) until a desired resolution is achieved, such that additional triangle edges identified as  
25 corresponding to a width between the inner contour and the outer contour are compared to identify  
26 the minimum and the maximum width.

27 ///

28 ///

29 ///

30 ///

1           3. (Original) The method of Claim 1, wherein the step of performing the low resolution  
2 triangulation function comprises the steps of:

3                   (a)     decomposing the inner contour into a low resolution inner contour set using  
4 wavelet analysis;

5                   (b)     decomposing the outer contour into a low resolution outer contour set using  
6 wavelet analysis; and

7                   (c)     computing tiling for the low resolution inner contour set and the low resolution  
8 outer contour set using greedy triangulation.

9           4. (Original) The method of Claim 1, wherein the step of analyzing the edges of the triangles  
10 using the minimal energy function comprises the step of using a Delaunay triangulation MaxMin  
11 angle property to determine the minimal energy function.

12           5. (Original) The method of Claim 4, wherein the step of analyzing edges of the triangles  
13 using the minimal energy function further comprises the step of performing an edge flipping  
14 operation on the edges of the triangles.

15           6. (Original) The method of Claim 1, wherein the step of adding additional triangles between  
16 the inner contour and the outer contour comprises the steps of:

17                   (a)     inserting additional vertices onto each of the inner contour and the outer  
18 contour, such that triangles defined between the inner contour and the outer contour are converted to  
19 quadrilaterals; and

20                   (b)     constructing an edge from each inserted vertex on one of the inner contour and  
21 the outer contour to a corresponding quadrilateral vertex on the other of the inner contour and the  
22 outer contour, thereby converting each quadrilateral into a pair of triangles.

23           7. (Original) The method of Claim 1, wherein steps (a)-(e) are at least partially executed  
24 automatically by a computing device.

25           8. (Currently Amended) The method of Claim 1, further comprising the step of using the  
26 inner ~~counter~~contour, the outer contour, the minimum width and the maximum width to calculate a  
27 plurality of morphological descriptors for the lumen.

28           9. (Currently Amended) The method of Claim 8, wherein the step of using the inner  
29 ~~counter~~contour, the outer contour, the minimum width and the maximum width to calculate a  
30 plurality of morphological descriptors comprises the step of calculating a plurality of area descriptors.

1           10. (Original) The method of Claim 9, wherein the step of calculating a plurality of area  
2 descriptors comprises the steps of calculating at least two of the following:

- 3                   (a)     an area of the lumen;
- 4                   (b)     an outer wall boundary area of the lumen;
- 5                   (c)     a wall area of the lumen; and
- 6                   (d)     a ratio of the area of the lumen to the outer wall boundary area.

7           11. (Currently Amended) The method of Claim 8, wherein the step of using the inner  
8 ~~counter~~contour, the outer contour, the minimum width and the maximum width to calculate a  
9 plurality of morphological descriptors comprises the step of calculating a plurality of simple  
10 descriptors, each simple descriptor being based on a one dimensional distance determined for the  
11 lumen.

12           12. (Original) The method of Claim 11, wherein the step of calculating a plurality of simple  
13 descriptors comprises the steps of calculating at least two of the following:

- 14                   (a)     a mean of lumen boundary radii;
- 15                   (b)     a minimum of the lumen boundary radii;
- 16                   (c)     a maximum of the lumen boundary radii;
- 17                   (d)     a ratio of the minimum of the lumen boundary radii to the maximum of the  
18 lumen boundary radii;
- 19                   (e)     a ratio of the minimum of the lumen boundary radii to the mean of the lumen  
20 boundary radii;
- 21                   (f)     a ratio of the mean of the lumen boundary radii to the maximum of the lumen  
22 boundary radii; and
- 23                   (g)     a ratio of a standard deviation of the lumen boundary radii to the mean of the  
24 lumen boundary radii.

25 ///

26 ///

27 ///

28 ///

29 ///

30 ///

1           13. (Original) The method of Claim 11, wherein the step of calculating a plurality of simple  
2 descriptors comprises the steps of calculating at least two of the following:

- 3                   (a)     a mean of outer wall boundary radii;  
4                   (b)     a minimum of the outer wall boundary radii;  
5                   (c)     a maximum of the outer wall boundary radii;  
6                   (d)     a ratio of the minimum of the outer wall boundary radii to the maximum of the  
7 outer wall boundary radii;  
8                   (e)     a ratio of the minimum of the outer wall boundary radii to the mean of outer of  
9 the wall boundary radii;  
10                  (f)     a ratio of the mean of the outer wall boundary radii to the maximum of the  
11 outer wall boundary radii; and  
12                  (g)     a ratio of a standard deviation of the outer wall boundary radii to the mean of  
13 the outer wall boundary radii.

14           14. (Original) The method of Claim 11, wherein the step of calculating a plurality of simple  
15 descriptors comprises the steps of calculating at least two of the following:

- 16                   (a)     a mean of all wall thicknesses of the lumen that were determined;  
17                   (b)     a ratio of the minimum wall thickness to the maximum wall thickness;  
18                   (c)     a ratio of the minimum wall thickness to the mean of all wall thicknesses;  
19                   (d)     a ratio of the mean of all wall thicknesses to the maximum wall thickness; and  
20                   (e)     a ratio of a standard deviation of all wall thicknesses to the mean of all wall  
21 thicknesses.

22           15. (Currently Amended) The method of Claim 8, wherein the step of using the inner  
23 ~~counter~~contour, the outer contour, the minimum width and the maximum width to calculate the  
24 plurality of morphological descriptors comprises the step of calculating a plurality of complexity  
25 descriptors, each complexity descriptor being based on two different dimensional distances  
26 determined for the lumen.

27 ///

28 ///

29 ///

30 ///

1           16. (Original) The method of Claim 15, wherein the step of calculating a plurality of  
2 complexity descriptors comprises the steps of calculating at least two of the following:

- 3                   (a) a ratio of a minimum of lumen radii to a mean of wall radii for the lumen;  
4                   (b) a ratio of a maximum of lumen radii to the mean of the wall radii;  
5                   (c) a ratio of a mean of the lumen radii to the mean of the wall radii; and  
6                   (d) a ratio of a distance between a centroid of the lumen and a centroid of the outer  
7 wall boundary to the mean of the wall radii.

8           17. (Original) The method of Claim 15, wherein the step of calculating a plurality of  
9 complexity descriptors comprises the steps of calculating at least two of the following:

- 10                   (a) a ratio of the minimum wall thickness to a mean of wall radii;  
11                   (b) a ratio of the maximum wall thickness to the mean of the wall radii; and  
12                   (c) a ratio of the mean of all wall thicknesses to the mean of the wall radii.

13           18. (Currently Amended) The method of Claim 8, wherein the step of using the inner  
14 ~~counter~~contour, the outer contour, the minimum width and the maximum width to calculate a  
15 plurality of morphological descriptors for the lumen comprises the step of calculating:

- 16                   (a) a plurality of area descriptors;  
17                   (b) a plurality of simple descriptors, each simple descriptor being based on a one  
18 dimensional distance determined for the lumen; and  
19                   (c) a plurality of complexity descriptors, each complexity descriptor being based  
20 on two different dimensional distances determined for the lumen.

21           19. (Original) The method of Claim 18, wherein each morphological descriptor is  
22 automatically calculated by a computing device.

23           20. (Original) The method of Claim 18, wherein the lumen is a blood vessel of a patient,  
24 further comprising the step of analyzing the plurality of morphological descriptors to evaluate  
25 whether the patient is at risk for having a stroke.

26           21. (Original) A memory medium on which machine executable instructions are stored for  
27 carrying out the steps of Claim 1.

28 ///

29 ///

30 ///

1           22. (Currently Amended) A method for estimating a thickness of a wall of a lumen,  
2 comprising the steps of:

3                   (a) identifying an inner contour and an outer contour of the lumen;  
4                   (b) generating a plurality of edges between the inner contour and the outer contour  
5 using multiresolution tiling;

6                   (c) analyzing the plurality of edges using a Delaunay triangulation minimal energy  
7 function to identify edges that correspond to a width between the inner contour and the outer contour;  
8 ~~and~~

9                   (d) comparing edges identified as corresponding to a width between the inner  
10 contour and the outer contour to identify a minimum width and a maximum width; and

11                   (e) having identified the minimum width and the maximum width, executing at  
12 least one step selected from the group consisting of the following steps:

13                           (i) storing indications of the minimum width and the maximum width for  
14 later use; and

15                           (ii) outputting indications of the minimum width and the maximum width  
16 to a user.

17           23. (Original) The method of Claim 22, further comprising the step of using the inner  
18 contour, the outer contour, the minimum width and the maximum width to calculate a plurality of  
19 morphological descriptors for the lumen.

20           24. (Currently Amended) The method of Claim 23, wherein the step of using the inner  
21 ~~outer~~contour, the outer contour, the minimum width and the maximum width to calculate a  
22 plurality of morphological descriptors comprises the step of calculating:

23                   (a) a plurality of area descriptors;

24                   (b) a plurality of simple descriptors, each simple descriptor being based on a one  
25 dimensional distance determined for the lumen; and

26                   (c) a plurality of complexity descriptors, each complexity descriptor being based on two  
27 different dimensional distances determined for the lumen.

28           25. (Original) A memory medium on which machine executable instructions are stored for  
29 carrying out the steps of Claim 22.

30 ///

1           26. (Currently Amended) A method for estimating a thickness of a wall of a lumen,  
2 comprising the steps of:

3                   (a)     identifying an inner contour and an outer contour of a lumen;  
4                   (b)     decomposing each of the inner contour and outer contour into a low resolution  
5 set of discrete points for the inner contour and a low resolution set of discrete points for the outer  
6 contour;

7                   (c)     employing a triangulation function to define triangles between the discrete  
8 points in each low resolution set;

9                   (d)     adding additional triangles between the inner contour and the outer contour;

10                  (e)     analyzing edges of the triangles that were defined and added to identify  
11 triangle edges that correspond to a width between the inner contour and the outer contour;

12                  (f)     comparing the triangle edges to identify a minimum width and a maximum  
13 width; and

14                  (g)     having identified the minimum width and the maximum width, executing at  
15 least one step selected from the group consisting of the following steps:

16                           (i)     storing indications of the minimum width and the maximum width for  
17 later use; and

18                           (ii)    outputting indications of the minimum width and the maximum width  
19 to a user.

20           27. (Original) The method of Claim 26, wherein the step of adding additional triangles  
21 between the inner contour and the outer contour comprises the steps of:

22                   (a)     inserting additional points onto each of the inner contour and the outer contour,  
23 such that triangles defined between the inner contour and the outer contour are converted to  
24 quadrilaterals; and

25                   (b)     constructing an edge from each point that was inserted to a corresponding  
26 quadrilateral vertex on the other contour, thereby converting each quadrilateral into a pair of  
27 triangles.

28           28. (Original) The method of Claim 26, wherein the step of analyzing triangle edges  
29 comprises the step of using a Delaunay triangulation MaxMin angle property to determine a minimal  
30 energy function.

1           29. (Original) The method of Claim 26, further comprising the steps of repeating steps (e)  
2 and (f) until a desired resolution is achieved, such that additional triangle edges identified as  
3 corresponding to the width between the inner contour and the outer contour are compared to identify  
4 the minimum width and the maximum width.

5           30. (Original) The method of Claim 26, further comprising the step of using the inner  
6 contour, the outer contour, the minimum width and the maximum width to calculate a plurality of  
7 morphological descriptors for the lumen.

8           31. (Original) A memory medium on which machine executable instructions are stored for  
9 carrying out the steps of Claim 26.

10 ///

11 ///

12 ///

13 ///

14 ///

15 ///

16 ///

17 ///

18 ///

19 ///

20 ///

21 ///

22 ///

23 ///

24 ///

25 ///

26 ///

27 ///

28 ///

29 ///

30 ///



32. (Currently Amended) A method for estimating a thickness of a wall of a lumen, comprising the steps of:

- (a) identifying an inner contour and an outer contour of the lumen;
- (b) decomposing the inner contour and the outer contour into a set of low resolution contours, to produce a pair of low resolution contour sets;
- (c) computing tiling to generate triangles for each low resolution contour set in which each triangle includes at least one cross edge extending between the inner contour and the outer contour;
- (d) labeling each cross edge as a suspect edge;
- (e) edge flipping each triangle relative to a cross edge thereof using a minimal energy function to identify cross edges that correspond to the width between the inner contour and the outer contour;
- (f) inserting a new vertex into each low resolution contour set, such that triangles defined by the pair of low resolution contour sets are converted to quadrilaterals;
- (g) constructing an edge from each inserted vertex in one of the low resolution sets of the pair to a corresponding quadrilateral vertex in the other low resolution contour set of the pair, to convert each quadrilateral into a pair of triangles;
- (h) labeling each cross edge as a suspect edge;
- (i) edge flipping each triangle relative to a cross edge thereof using the minimal energy function, to identify cross edges that correspond to the width between the inner contour and the outer contour;
- (j) repeating steps (f)-(i) until a desired resolution is achieved; ~~and~~
- (k) comparing cross edges identified as corresponding to the width between the inner contour and the outer contour to identify a minimum width and a maximum width; and
- (l) having identified the minimum width and the maximum width, executing at least one step selected from the group consisting of the following steps:
  - (i) storing indications of the minimum width and the maximum width for later use; and
  - (ii) outputting indications of the minimum width and the maximum width to a user.

1           33. (Original) The method of Claim 32, further comprising the step of using the inner  
2 contour, the outer contour, the minimum width and the maximum width to calculate a plurality of  
3 morphological descriptors for the lumen.

4           34. (Original) A memory medium on which machine executable instructions are stored for  
5 carrying out the steps of Claim 32.

6           35. (Currently Amended) A system for analyzing a lumen to determine dimensions of the  
7 lumen, including wall thickness, comprising:

8                   (a)     imaging apparatus that produce an image of a lumen within a body of a patient;  
9 and

10                   (b)    a computing device coupled to the imaging apparatus to control it, said  
11 computing device including:

12                           (i)     a memory in which machine instructions are stored; and

13                           (ii)    a processor coupled to the memory, said processor executing the  
14 machine instructions to control the imaging apparatus to carry out a plurality of operations, including:

15                                   (1)     identifying an inner contour and an outer contour of the lumen;

16                                   (2)     generating a plurality of edges between the inner contour and  
17 the outer contour using multiresolution tiling;

18                                   (3)     analyzing the plurality of edges using a Delaunay triangulation  
19 minimal energy function to identify edges that correspond to a width between the inner contour and  
20 the outer contour; ~~and~~

21                                   (4)     comparing edges identified as corresponding to a width between  
22 the inner contour and the outer contour to identify a minimum width and a maximum width between  
23 the inner contour and the outer contour, corresponding respectively to a minimum wall thickness and  
24 a maximum wall thickness of the lumen; and

25                                   (5)     having identified the minimum width and the maximum width,  
26 executing at least one step selected from the group consisting of the following steps:

27   (i)     storing indications of the minimum width and the  
28 maximum width for later use; and

29   (ii)    outputting indications of the minimum width and the  
30 maximum width to a user.

1           36. (Original) The system of Claim 35, further comprising a display coupled to the  
2 processor, wherein the machine instructions further cause the processor to display a discrete image of  
3 a selected slice of the lumen

4           37. (Original) The system of Claim 35, wherein the machine instructions further cause the  
5 processor to calculate a plurality of morphological descriptors for the lumen, the morphological  
6 descriptors including:

7                   (a) a plurality of area descriptors;

8                   (b) a plurality of simple descriptors, each simple descriptor being based on a one  
9 dimensional distance determined for the lumen; and

10                  (c) a plurality of complexity descriptors, each complexity descriptor being based  
11 on two different dimensional distances associated with the lumen.

12 ///

13 ///

14 ///

15 ///

16 ///

17 ///

18 ///

19 ///

20 ///

21 ///

22 ///

23 ///

24 ///

25 ///

26 ///

27 ///

28 ///

29 ///

30 ///

1           38. (Currently Amended) A system for analyzing a lumen to determine dimensions of the  
2 lumen, including wall thickness, comprising:

3                   (a) a computer configured to process an image of a lumen, said computer  
4 including:

5                           (i) a memory in which machine instructions are stored;  
6                           (ii) a display configured to display an image of a lumen; and  
7                           (ii) a processor coupled to the memory and the display, said processor  
8 executing the machine instructions to carry out a plurality of operations, including:

9                                   (1) in an image of the lumen, identifying an inner contour and an  
10 outer contour;

11                                   (2) performing a low resolution triangulation function to define  
12 triangles between the inner contour and the outer contour;

13                                   (3) adding additional triangles between the inner contour and the  
14 outer contour;

15                                   (4) analyzing edges of the triangles that were defined and added  
16 using a minimal energy function to identify triangle edges that correspond to a width between the  
17 inner contour and the outer contour; ~~and~~

18                                   (5) comparing triangle edges identified as corresponding to a width  
19 between the inner contour and the outer contour to identify a minimum width and a maximum width  
20 corresponding respectively to a minimum wall thickness and a maximum wall thickness of the  
21 lumen; and

22                                   (6) having identified the minimum width and the maximum width,  
23 executing at least one step selected from the group consisting of the following steps:

24   (i) storing indications of the minimum width and the  
25 maximum width for later use; and

26   (ii) outputting indications of the minimum width and the  
27 maximum width to a user.

28 ///

29 ///

30 ///

1           39. (Original) The system of Claim 38, wherein the machine instructions further cause the  
2 processor to iteratively add additional triangles between the inner contour and the outer contour until  
3 a predetermined resolution is achieved.

4           40. (Currently Amended) The system of Claim 38, wherein the machine instructions further  
5 cause the processor to perform the low resolution triangulation function by implementing the  
6 following operations:

7                   (a)     decomposing the inner contour into a low resolution inner contour set using  
8 wavelet analysis, and decomposing the outer contour into a low resolution outer contour set using  
9 wavelet analysis ; and

10                  (b)     computing tiling for the low resolution inner contour set and the low resolution  
11 outer contour set using greedy triangulation.

12           41. (Original) The system of Claim 38, wherein the machine instructions further cause the  
13 processor to analyze the edges of the triangles using a Delaunay triangulation MaxMin angle property  
14 to determine the minimal energy function.

15           42. (Original) The system of Claim 38, wherein the machine instructions further cause the  
16 processor to analyze triangle edges by performing an edge flipping operation on the edges of the  
17 triangles.

18           43. (Original) The system of Claim 38, wherein the machine instructions further cause the  
19 processor to add additional triangles between the inner contour and the outer contour by  
20 implementing the following operations:

21                   (a)     inserting vertices onto each of the inner contour and the outer contour, such  
22 that triangles defined between the inner contour and the outer contour are converted to quadrilaterals;  
23 and

24                   (b)     constructing an edge from each inserted vertex on one of the inner contour and  
25 the outer contour to a corresponding quadrilateral vertex on the other of the inner contour and the  
26 outer contour, thereby converting each quadrilateral into a pair of triangles.

27 ///

28 ///

29 ///

30 ///

1           44. (Original) The system of Claim 38, wherein the machine instructions further cause the  
2 processor to calculate a plurality of morphological descriptors for the lumen, the morphological  
3 descriptors including:

4                   (a)     a plurality of area descriptors;

5                   (b)     a plurality of simple descriptors, each simple descriptor being based on a one  
6 dimensional distance determined for the lumen; and

7                   (c)     a plurality of complexity descriptors, each complexity descriptor being based  
8 on two different dimensional distances determined for the lumen.